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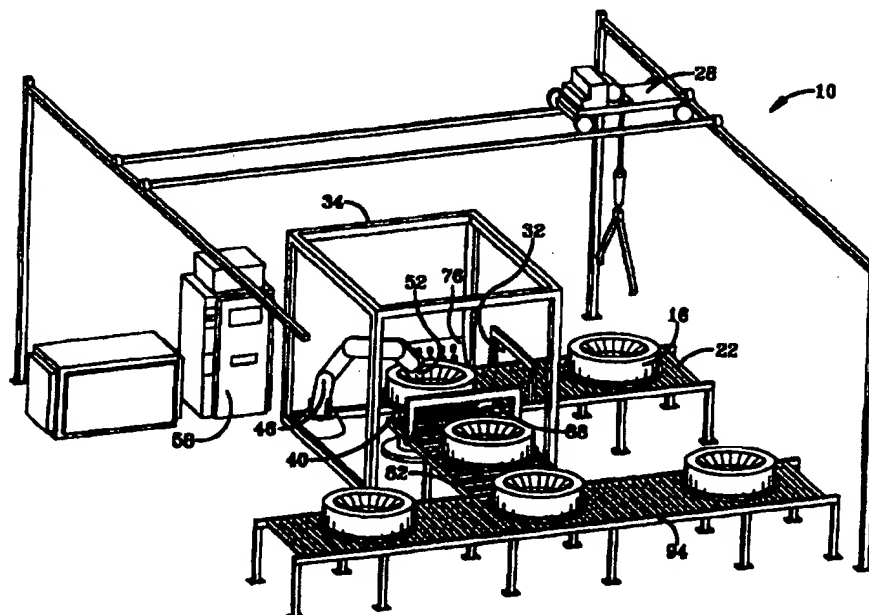
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(54) Title: ROBOTIC CO₂ TIRE MOLD CLEANING

(57) Abstract

A method and apparatus for cleaning molds, particularly tire molds (16) using pellets of a frozen gas and a robotically controlled apparatus are disclosed. A heated mold (16) is conveyed into an insulated and sound-proof enclosure (34) where a robot arm with a nozzle (52) mounted on the robot arm directs frozen CO₂ pellets against the mold surface to be cleaned. The mold (16) is rotated on a rotary table (40) to clean the entire mold surface. The mold (16) is then removed from the enclosure (34) on a conveyor (82). The preferred frozen gas is CO₂ because it is non-abrasive to the tire mold surfaces and also cleans the microvents of the tire mold (16).

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ROBOTIC CO₂ TIRE MOLD CLEANING

Technical Field

This invention pertains to the art of methods and apparatuses for cleaning tire molds, and more specifically to methods and apparatuses for cleaning tire molds using pellets of frozen carbon dioxide, hereafter referred to as CO₂.

Background Art

In the past, two-piece tire molds and segmented tire molds were cleaned in semi-automatic machines which used metal shot, plastic beads, or glass beads as the cleaning or blasting agent. All of these blasting agents were abrasive and caused rapid wear to tire mold lettering and sidewall designs. Additionally, these blasting agents and machines were incapable of removing trapped materials from microvents in the tire molds. Therefore, microvents had to be drilled manually to remove trapped materials.

Another problem encountered by the past machines was recovery of the blasting agent, such as sand or glass beads. After the blasting agent had been used to clean a tire mold, it had to be recovered or removed. The recovery of the blasting agent increased the time necessary to clean tire molds and caused a contamination problem in the plant.

One such abrasive tire blasting apparatus is found in U.S. Patent No. 3,905,155 to Smith et al., which discloses a machine that provides a removable hood for positioning over a tire mold and blasts the tire mold with abrasive glass beads.

Applicants recognized a need for a method and apparatus for cleaning tire molds with a blasting agent that was less abrasive than the prior blasting agents and required less recovery time. Additionally, a method and apparatus for cleaning the microvents of a tire mold was also needed.

The present invention contemplates a new and improved tire mold cleaning method and apparatus which is simple in design, effective in use, and overcomes the foregoing difficulties and others while providing better and more advantageous overall results.

Disclosure of Invention

In accordance with the present invention, a new and improved method and apparatus for cleaning a mold, particularly a tire mold, is provided which uses CO₂ pellets to clean the tire mold.

According to one aspect of the present invention there is provided an apparatus for cleaning a tire mold with CO₂ pellets directed against the molding surfaces of the tire mold. The apparatus includes a sound-proof insulated enclosure for the tire mold, a rotatable support for positioning and rotating the tire mold in the enclosure, a robot in the enclosure

that has an arm moveable to select cleaning positions over the molding surfaces of the tire mold, a nozzle mounted on the arm and in communication with a source of CO₂ pellets, a robot control apparatus for rotating the arm to position the nozzle over the molding surfaces to direct the CO₂ pellets against the molding surfaces in a direction substantially perpendicular to the molding surfaces at different positions axially of the tire mold, and a power apparatus for rotating the rotatable support while the CO₂ pellets are directed against the molding surfaces.

According to another aspect of the present invention there is provided a method of cleaning the tire mold with CO₂ pellets directed against the molding surfaces of the tire mold. This method includes the steps of supporting the tire mold on a rotatable support in a sound-proof insulated enclosure, and communicating CO₂ pellets to the molding surfaces from a pellet mixer by air pressure to a nozzle adjacent the molding surfaces and moving the nozzle axially within the tire mold while rotating the tire mold about an axis on the rotatable support to traverse the molding surfaces.

One advantage of the present invention is that the cleaning apparatus is completely automatic.

Another advantage of the present invention is that the CO₂ pellets are non-abrasive and do not damage the tire mold.

Another advantage of the present invention is that the CO₂ pellets melt and evaporate after contacting the tire mold, thereby eliminating the need to recover used blasting agents.

Another advantage of the present invention is that the frozen CO₂ pellets also clean microvents in the tire molds, thereby eliminating the need to drill the microvents manually.

Still other benefits and advantages of the invention will become apparent to those skilled in the art to which it pertains upon a reading and understanding of the following detailed specification.

Brief Description of Drawings

The invention may take physical form in certain parts and arrangement of parts, a preferred embodiment of which will be described in detail in this specification and illustrated in the accompanying drawings which form a part hereof and herein:

Figure 1 is a schematic view of a robotic CO₂ cleaning apparatus;

Figure 2 is a detailed view of a spray nozzle with a closed flow regulator and safety shut off;

Figure 3 is a detailed view of the spray nozzle like Figure 2 with an open

flow regulator;

Figure 4 is a plan view of a preferred embodiment of a robotic CO₂ cleaning apparatus;

Figure 5 is a front elevation of the robotic CO₂ cleaning apparatus of Figure 4; and,

Figure 6 is an enlarged fragmentary view of one of the rotary tables and the spray nozzle as used with robotic CO₂ cleaning apparatus of Figures 3, 4, and 5.

Detailed Description of the Invention

Referring now to the drawings wherein the showings are for purposes of illustrating one embodiment of the invention only and not for purposes of limiting the same, Figure 1 shows a schematic view of a robotic CO₂ cleaning apparatus 10. A segmented tire mold 16, is placed onto an entry conveyor 22 by a hoist 28. The tire mold 16 is heated with steam so that the tire mold placed on the entry conveyor 22 is heated to a temperature of approximately 350°F (177°C). The tire mold 16 is heated to near the curing temperature of the tire to facilitate the rapid removal of material from the tire mold 16 during the cleaning process.

The entry conveyor 22 conveys the tire mold 16 through an opening 32 into an enclosure 34 that is preferably sound-proof and insulated. The opening 32 may include a door (not shown) that closes the opening when the cleaning apparatus 10 is in operation. The enclosure 34 is preferably sound-proof to reduce noise that may be objectionable to employees working around the cleaning apparatus 10. The enclosure 34 is preferably insulated to maintain the temperature of the tire mold 16 as near the tire curing temperature as is feasible.

Inside the enclosure 34, the tire mold 16 is transferred to a rotary table 40 and cleaned by a robot 46 directing frozen CO₂ pellets against the mold surfaces. The frozen CO₂ pellets preferably have diameters between 0.04 inch and 0.12 inch and temperatures of about -80°F (-62°C). Frozen CO₂ is preferred because such pellets are non-abrasive, thereby extending the life of the tire mold 16 and improving the appearance of the tire produced by the tire mold. Additionally, the frozen CO₂ evaporates on contact with the tire mold 16, producing a pressurized gas that cleans out the microvents of the tire mold. Also, since the CO₂ pellets evaporate on contact with the tire mold 16, housekeeping is improved because no blasting agents are deposited on the other equipment or on the floor..

Before cleaning, the segmented tire mold 16 need not be disassembled and is

conveyed onto a rotary table 40 rotatable about the axis and controlled by a servomotor (not shown). The rotary table 40 rotates the tire mold 16 past a spray nozzle 52 of a robot 46. The spray nozzle 52 is attached to the end of the robot 46. The robot 46 is multi-directional, preferably being a six axis robot, so that the spray nozzle 52 may be adjusted to clean an entire tire mold 16. The spray nozzle 52 is preferably adjusted by the robot 46 to aim a stream of frozen CO₂ pellets in a direction normal to the surface of the tire mold 16 that is being cleaned. The speed at which the rotary table 40 rotates is adjustable as is the robot 46 positioning of the spray nozzle 52 to optimize the cleaning action of the cleaning apparatus 10. The rotational speed of the rotary table 40 and the position of the spray nozzle 52 at the end of the robot 46 are preferably regulated by a fully programmable robot controller 58. Also a safety shut off 72 is interposed between the spray nozzle 52 and the robot to shut down the apparatus if the spray nozzle engages the mold 16 during the cleaning.

Figure 2 shows a close-up view of the spray nozzle 52. The spray nozzle 52 is preferably curved slightly to enable the robot 46 to position the spray nozzle to clean a variety of different curved surfaces of the tire mold 16. The end of the spray nozzle 52 has a flow regulator 64 that regulates the flow of frozen CO₂ pellets through the end of the spray nozzle. The flow regulator 64 may be closed completely to prohibit the flow of frozen CO₂ pellets, or, as shown in Figure 3, the flow regulator may be opened up to a diameter 70 of 1.0 inch to increase the flow of frozen CO₂ pellets.

Liquid nitrogen (N₂) may be injected into the air delivery system to super cool the frozen CO₂ pellets to ensure that the pellets do not disintegrate or evaporate before they are delivered as a blasting agent.

With further reference to Figure 1, after the tire mold 16 is cleaned by the cleaning apparatus 10, a mold pusher 76 pushes the tire mold 16 off the rotary table 40 and onto an exit conveyor 82. The exit conveyor 82 conveys the tire mold 16 out of the enclosure 34 through a second opening 88 in the enclosure. The second opening 88 may have a door (not shown) which closes the opening when the cleaning apparatus is in operation. The tire mold 16 is then transferred to a staging conveyor 94 where it awaits transport back into the tire production process. A tire mold 16 may be cleaned in approximately ten minutes using the cleaning apparatus 10.

Figures 4-6 show a preferred embodiment of the invention. The robotic CO₂ cleaning apparatus 10 is preferably enclosed in a special enclosure 100 that has two doors

106,108. The doors 106,108 open to allow a tire mold 16 to be placed in the enclosure 100, and then the doors are closed before the robotic CO₂ cleaning apparatus is activated. The doors 106,108 preferably have windows to allow an operator to see the tire mold 16 as it is cleaned.

5 As shown in Figures 4 and 5, this preferred embodiment features two rotary tables 114,116 located on opposite sides of the robot 46. Each rotary table 114,116 has a centering apparatus that consists of preferably three radially movable centering guide members 122 that operate to center a tire mold 16 or mold half on each rotary table about an axis of rotation of the table after the tire mold half is placed on each of the rotary tables by the hoist 28. As with the previous embodiment, each tire mold 16 to be cleaned is heated to
10 approximately 350°F (177°C) to optimize the cleaning procedure.

Once centered, the rotary tables 114,116 rotate each tire mold 16 as the robot 46 positions the spray nozzle 52 normal to the mold surface of one of the tire molds to be cleaned, as illustrated in Figure 6. The spray nozzle 52 shown in solid lines illustrates the
15 position of the spray nozzle for cleaning the sidewall surface 128 of the tire mold 16. The spray nozzle 52a shown in dotted lines shows the position of the spray nozzle for cleaning the tread surface 130 of the tire mold 16. The spray nozzle 52b shown in dotted lines shows the position of the spray nozzle for cleaning the bead surface 132 of the tire mold half 16. The rotary tables 114,116 rotate each tire mold 16 about an axis of the tables past the spray
20 nozzle 52 for a specified number of rotations to ensure thorough cleaning. The number of rotations may be controlled by a robot controller (not shown) programmed to meet mold cleaning specifications, or an operator may manually control the cleaning of a tire mold 16 by controlling the number of rotations of one of the rotary tables 114,116 or the positioning of the robot 46. In the preferred embodiment of the present invention, the rotary tables
25 114,116 rotate from 2 rpm to 4 rpm for ten revolutions to clean each of the tread surfaces 130, the sidewall surfaces 128, and the bead surfaces 132 of the tire mold halves 16. The number of revolutions and speed of rotation may be adjusted as necessary.

While the preferred embodiment has been described with two rotary tables 114,116, any number of rotary tables may be employed that will fit around and be in reach of the
30 robot 46. Also the robot 46 may be mounted on a movable support to service additional molds.

The preferred embodiments have been described, hereinabove. It will be apparent to those skilled in the art that the above apparatus and methods may incorporate changes and

modifications without departing from the general scope of this invention. It is intended to include all such modifications and alterations in so far as they come within the scope of the appended claims or the equivalents thereof.

Having thus described the invention, it is now claimed:

CLAIMS

1. Apparatus for cleaning a tire mold with pellets directed against molding surfaces of said portion of said tire mold, characterized by:

a sound-proof insulated enclosure for said tire mold;

5 a rotatable support for positioning and rotating said portion of said tire mold in said enclosure;

a robot in said enclosure having an arm moveable to select cleaning positions over said molding surfaces of said tire mold;

a nozzle mounted on said arm and in communication with a source of pellets;

10 robot control means for rotating said arm to position said nozzle over said molding surfaces to direct said pellets against said molding surfaces; and

power means for rotating said rotatable support while said pellets are directed against said molding surfaces.

15 2. The apparatus of claim 1 wherein said pellets are directed against said molding surfaces in directions substantially perpendicular to said molding surfaces at different positions axially of said tire mold.

3. The apparatus of claim 2 characterized in that said pellets are frozen CO₂.

4. Apparatus in accordance with claim 3 further characterized by a second rotatable support for a second tire mold being located in said sound-proof insulated enclosure adjacent
20 said robot and at a position for said arm to move to selected cleaning positions over said molding surfaces of a second tire mold.

5. Apparatus in accordance with claim 1 further characterized by said sound-proof insulated enclosure having at least one movable door for closing an opening in said sound-proof insulated enclosure and an overhead hoist extending from a position over said opening
25 to a position spaced from said sound-proof insulated enclosure for conveying said tire mold into and out of said sound-proof insulated enclosure.

6. Apparatus in accordance with claim 5 further characterized by a second opening and a second movable door for said second opening, to provide for said tire mold entering said sound-proof insulated enclosure through said first opening and exiting said sound-proof
30 insulated enclosure through said second opening.

7. A method of cleaning a tire mold with pellets propelled against a molding surface of said tire mold characterized by the steps of:

supporting said tire mold on a rotatable support in a sound-proof insulated

enclosure for rotation about ab axis of said support; and,

communicating CO₂ pellets to said molding surface from a pellet mixer by applying air pressure to a nozzle adjacent said molding surface and moving said nozzle axially of said support while rotating said tire mold on said support to traverse said molding surface.

8. The method of claim 7 wherein said nozzle is mounted on an arm of a robot in said sound-proof insulated enclosure, characterized by said arm being moveable axially of said support.

9. The method of claim 8 characterized by a second molding surface of a second tire mold mounted on a second rotatable support in said sound-proof insulated enclosure wherein said second molding surface is cleaned by moving said arm of said robot to a position adjacent said second molding surface of said tire mold.

10. The method of claim 7 characterized by said tire mold being heated to a temperature of about 350°F (177°C), said CO₂ pellets being from .040 to 0.12 inches in diameter and at a temperature of -80°F (-62°C), said rotatable support rotating from 2 rpm to 4 rpm for 10 revolutions to clean a sidewall surface, 2 to 4 rpm for 10 revolutions to clean each bead surface and 2 to 4 rpm for 10 revolutions to clean each tread surface.

11. An apparatus for cleaning a tire mold, said apparatus comprising:

source means for providing pellets;

propelling means for propelling said pellets against the surface to be cleaned, characterized in that said pellets comprise a frozen gas.

12. The apparatus of claim 11 characterized by said pellets being frozen CO₂.

13. The apparatus of claim 11 further characterized by:

directing means for directing said pellets at desired locations on molding surfaces of said tire mold.

14. The apparatus of claim 13 further characterized by said directing means comprising a six axis robot.

15. The apparatus of claim 11 further characterized by:

rotating means for rotating said tire mold.

16. The apparatus of claim 15 further characterized by said rotating means comprising: a first positioning table, comprising a first servo motor and a first control means for rotating said first positioning table.

17. The apparatus of claim 16 further characterized by said rotating means comprising:

a second positioning table comprising a second servo motor and second control means for rotating said second positioning table.

18. A method of cleaning a tire mold, said method characterized by the step of:
directing pellets against a mold surface to be cleaned, characterized in that the pellets comprise a frozen gas.

19. The method of claim 18 further characterized by the step of:
rotating said mold.

20. The method of claim 19 further characterized by the step of:
moving a nozzle in an axial pattern so that an interior of said mold is cleaned.

21. The method and apparatus substantially as described herein or as shown in the accompanying drawings.

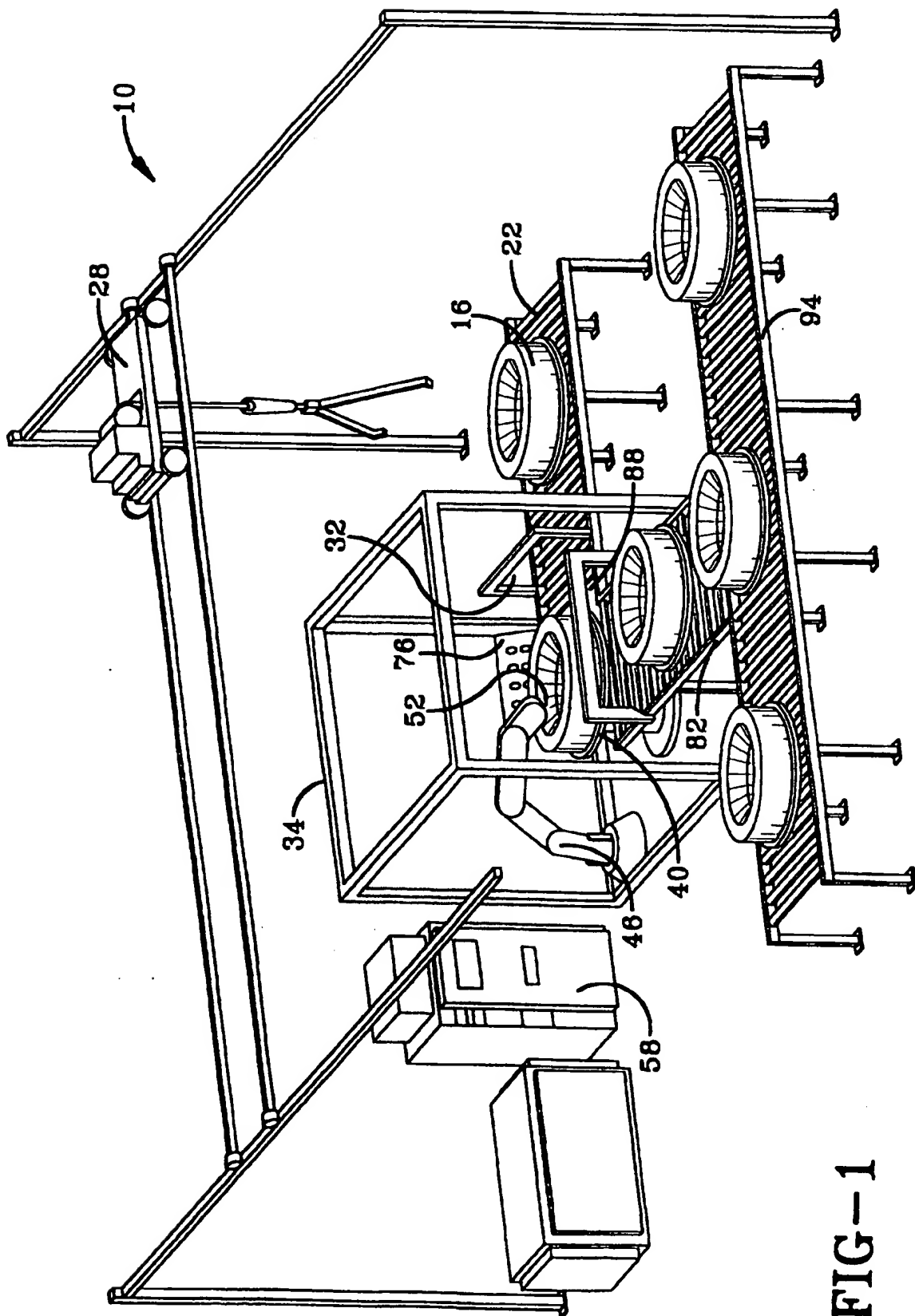
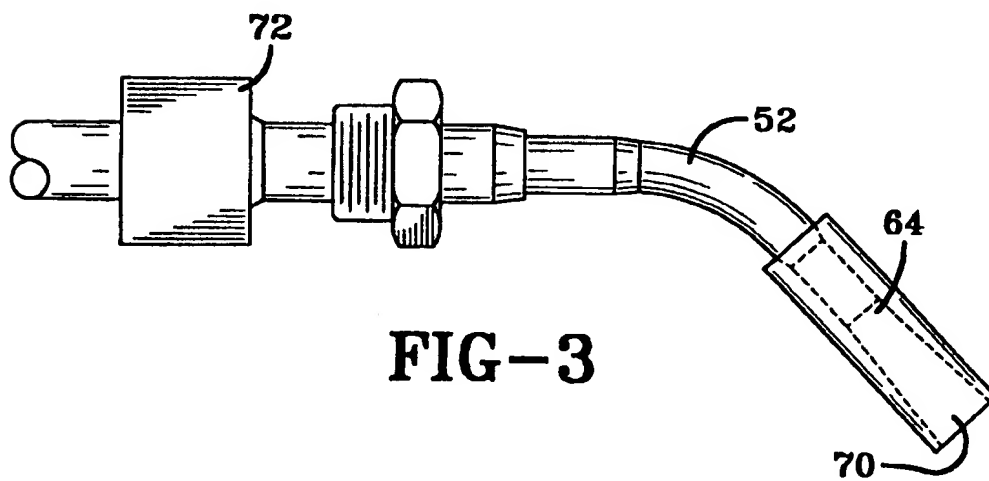
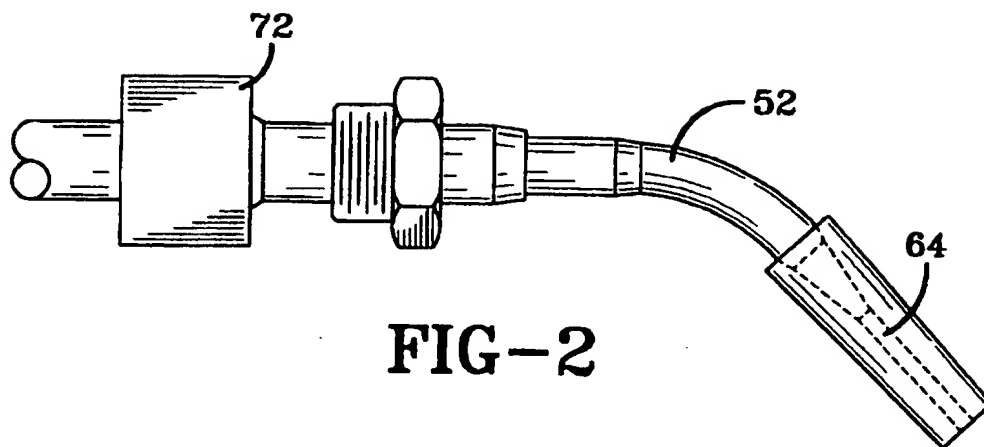
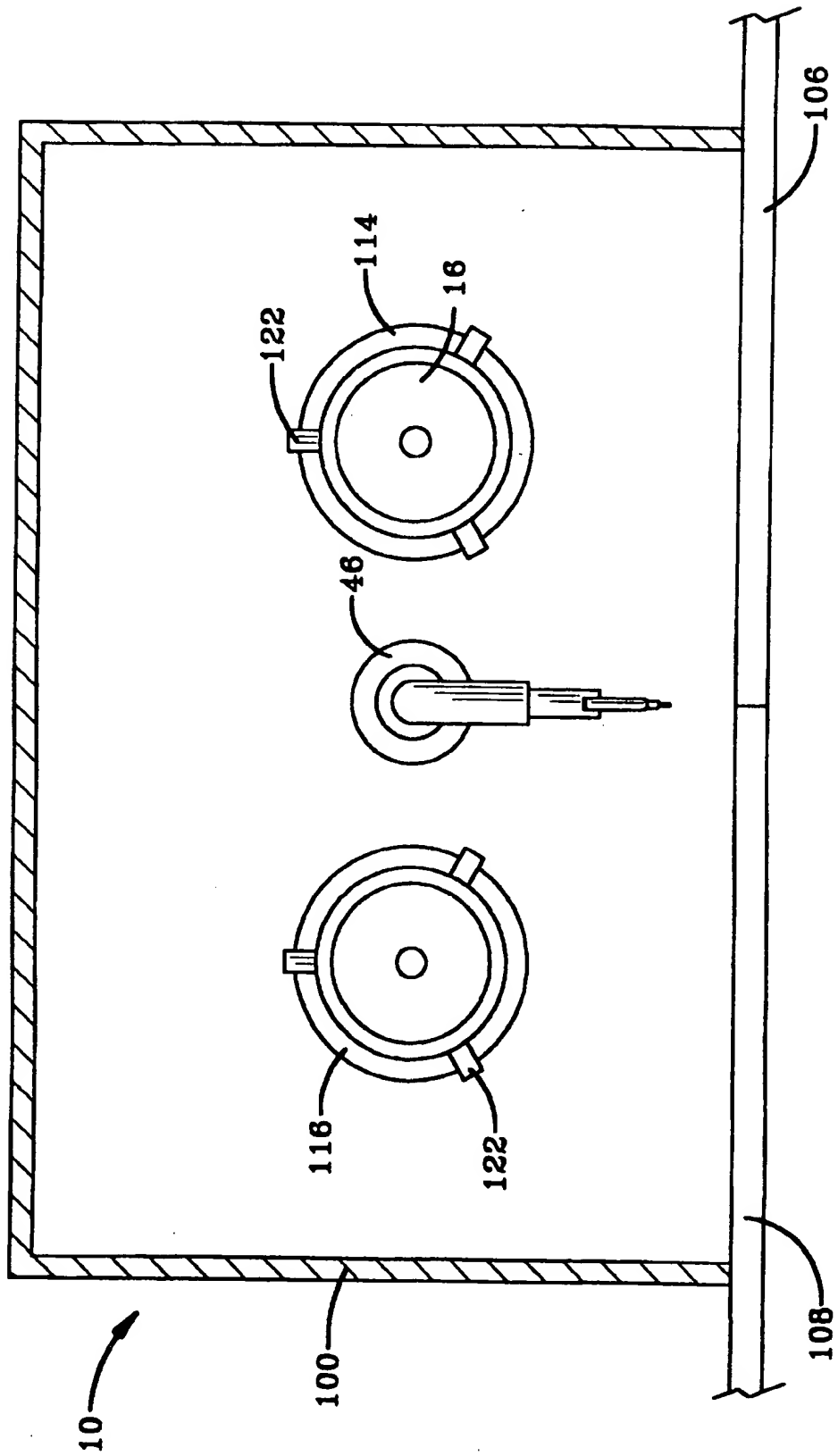


FIG-1





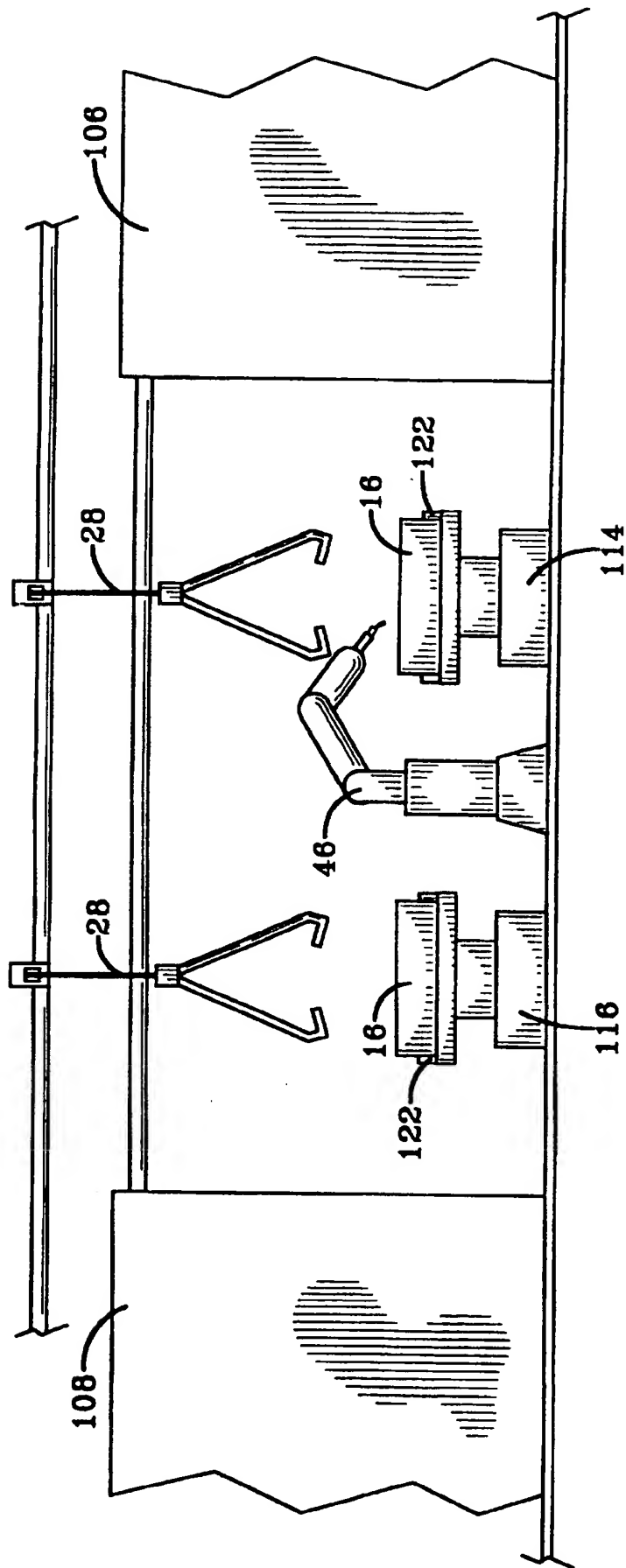


FIG-5

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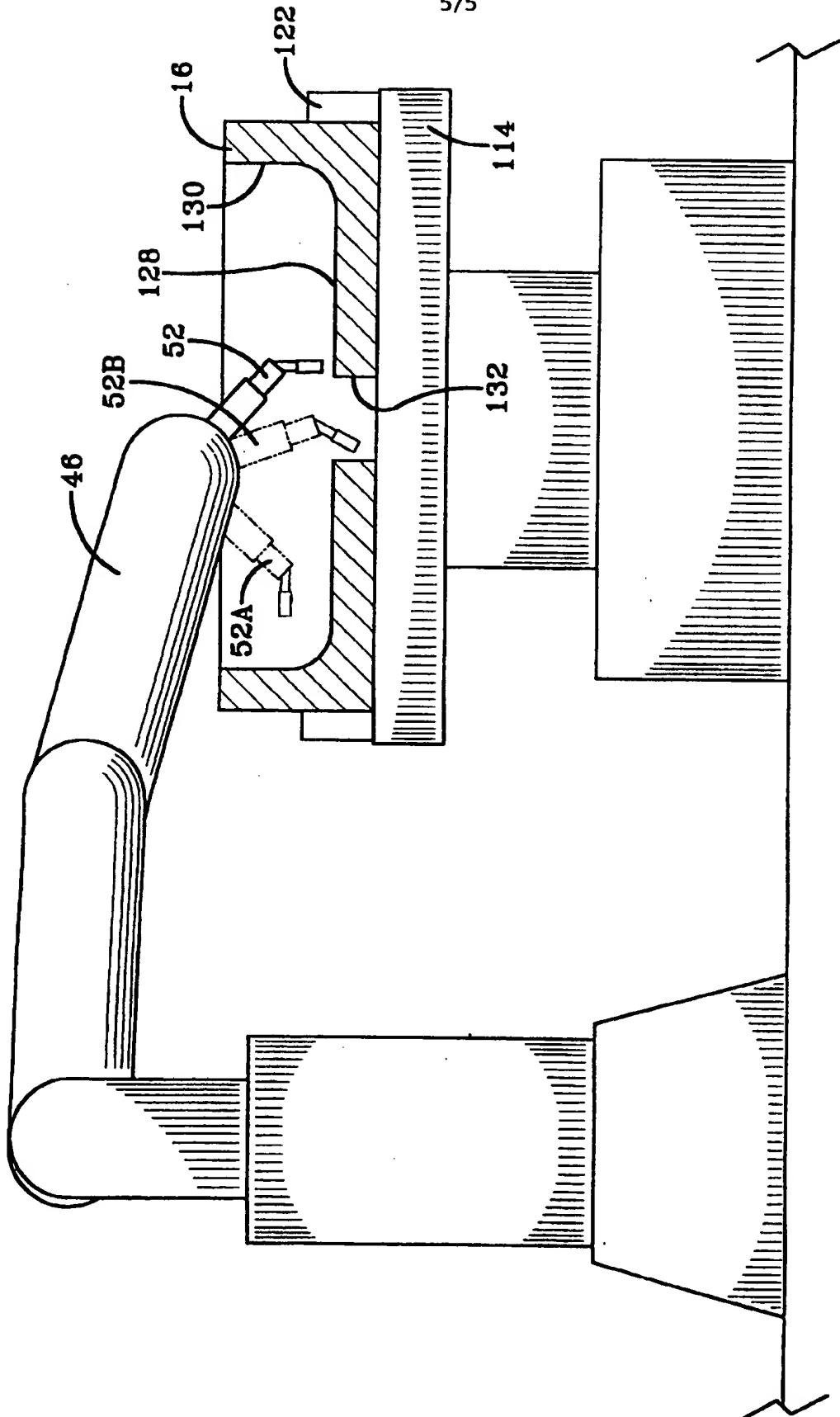


FIG-6

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 96/13521

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B24C1/00 B24C3/08 B24C3/22 B24C3/32 B29C33/72

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B24C B29C B08B B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	INTERNATIONAL POLYMER SCIENCE AND TECHNOLOGY, vol. 12, no. 11, 1985, XP002030075 "MOULD CLEANING METHODS. PART II. DRY BLASTING" see page 49	1-3,5,7, 8,11-13, 15,16, 18-20
Y	--- US 5 364 472 A (HEYNS GARRETT J ET AL) 15 November 1994 see the whole document	1-3,5,7, 8,11-13, 15,16, 18-20
A	--- US 3 905 155 A (SMITH LEONARD R ET AL) 16 September 1975 cited in the application see abstract --- -/--	1,2

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

24 April 1997

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/13521

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 4, no. 57 (M-9) [539] , 26 April 1980 & JP 55 024751 A (SUMITOMO GOMU KOGYO K.K.), 22 February 1980, see abstract ---	1
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(information on patent family members)

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